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THESIS

THE WARRANTY GUARANTY CLAUSE:
AN ANALYSIS OF ITS USE ON THE SPRUANCE
CLASS (DD-963) SHIPBUILDING CONTRACT AND
IDENTIFICATION OF LESSONS LEARNED

by

James T. Freihofer

and

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March 1983

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle) The Warranty Guaranty Clause: An Analysis of its Use on the Spruance Class (DD-963) Shipbuilding Contract and Identification of Lessons Learned

5. TYPE OF REPORT & PERIOD COVERED
Master's Thesis; March 1983

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
James T. Freihofer
Daniel S. Beach

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
March 1983

13. NUMBER OF PAGES
91

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Guaranty, Warranty, Workmanship, Defective material, Contractor liability, Shipbuilding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
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DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block #20 Contd.

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The Warranty Guaranty Clause: An Analysis of its Use on the Spruance Class (DD-963) Shipbuilding Contract and Identification of Lessons Learned

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MASTER OF SCIENCE IN MANAGEMENT

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ABSTRACT

The extension of contractor liability beyond delivery is an essential element in contracting when complex weapons systems are involved. Warranty/Guaranty clauses are currently being included in shipbuilding contracts as a means of incentivizing contractors to provide quality workmanship and materials. The authors have investigated the results of one Warranty/Guaranty effort, the U.S. Navy's Spruance Class Shipbuilding Program, and constructed a Cost-Effectiveness Model to evaluate actual performance on three ships of that Class. Lessons learned are identified and presented which could be incorporated into future Warranty/Guaranty policy decisions.

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I. INTRODUCTION

The extension of contractor liability beyond delivery is an essential element in contracting when complex weapons systems are involved. Modern weapons platforms are so technically complex that it is virtually impossible to test and accept them in a short period of time. Quality assurance and acceptance testing must be performed under actual conditions, which necessitate warranty periods that extend well beyond the initial delivery date.

Warranty/Guaranty clauses are currently being included in shipbuilding contracts as a means of incentivizing contractors to provide quality workmanship. By putting the contractors on notice that they will be held accountable for defective workmanship and materials, these clauses provide the government's contractual right to assert claims regarding defects discovered after acceptance of the weapons system, and they set forth the rights and obligations of both parties. Warranty clauses are specifically written not to narrow any rights afforded the government under the provisions of the inspections clause relating to latent defects, fraud, and gross mistakes.

> "These rights include correction of deficiencies or defects, reperformance, and equitable adjustment in the contract price or other remedies as required." [Ref. 1]

Various contract types and warranty coverage periods have been used in the past. Extensive literature searches indicate no prior effort has been made to review a completed warranty program of this type in order to identify lessons that might have been learned, evaluate those lessons, or make recommendations which could be incorporated into future warranty/guaranty policy. This thesis will attempt to identify, based on three case studies of DD-963 class ships, lessons learned and their implications on future policy development.

A. GENERAL

The major focus of this thesis is to review the Spruance class destroyer (DD-963) warranty/guaranty program. The methodology is in-depth case study on three ships of the class. The goal is to review the actual performance of the contract warranty/guaranty provisions in order to arrive at lessons learned. These lessons could become the basis for future planning of shipbuilding warranty/guaranty coverage.

B. RESEARCH QUESTIONS

1. Was there an underlying pattern for deficient work identification throughout the Spruance class destroyer acquisition program?

2. Was the one-year warranty clause utilized in this contract cost-effective?

3. What was the optimal length of time for the warranty period in this shipbuilding program based on the historical data reviewed?

4. How effective was the Navy's maintenance and material management (3M) system in recording warranty/guaranty work items and ship's force man hours expended in support of the warranty/guaranty coverage?

5. Should the lessons learned on this particular shipbuilding contract clause be incorporated in future shipbuilding contracts to reduce contract costs?

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

1. Scope

This research is limited to the Spruance class (DD-963) shipbuilding program. Other shipbuilding programs will not be discussed or compared. Three Spruance class ships, USS Leftwich (DD-984), USS Thorn (DD-988) and USS Fletcher (DD-992), will be investigated within the framework of the research questions posed.

2. Limitations

Operational scheduling considerations of new construction ships are complex. The possible scheduling problems created by the shortening of the warranty period were not researched.

3. Assumptions

It is assumed that the reader of this thesis has a basic knowledge of the U.S. shipbuilding industry, U.S. Navy

weapons systems acquisition process and U.S. Government procurement policy.

It has also been assumed that the length of a warranty period directly affects the amount of risk a contractor is exposed to in warranty programs. Increased risk translates to increased cost for the government.

D. METHODOLOGY

The research was conducted in three phases. An initial literature search was conducted to gain a basic understanding of the warranty concept and the Spruance class shipbuilding effort. This was followed by extensive archival research of cost data, work deficiency reports and ships' histories. Statistical techniques were used to reduce the data and provide insight into trends that occurred. A cost-effectiveness model was constructed to analyze the actual performance of the warranty/guaranty program on three ships of the class. Finally, a more detailed literature review was pursued and several interviews were conducted with representatives from the Naval Sea Systems Command, the Supervisor of Shipbuilding, Conversion and Repair (SUPSHIP), Pascagoula, Mississippi, and Ingalls Shipbuilding, Litton Industries to develop the issues.

1. Initial Literature Search

The primary source of literature in this search was the Defense Logistics Study Information Exchange (DLSIE).

This provided background articles and presentations on current warranty issues within the Department of Defense.

2. Archival Research

The records of the Supervisor of Shipbuilding, Conversion and Repair, Pascagoula, Mississippi and Ingalls Shipbuilding Division of Litton Industries provided background information and cost data on the program.

3. Interviews

Two approaches were used in interviews: telephone interviews were used for people in the Naval Sea Systems Command and personal interviews were conducted with representatives from both Ingalls and SUPSHIP Pascagoula.

4. Detailed Literature Search

A computer search of the ABI/INFORM database was conducted by the Dudley Knox Library at the Naval Postgraduate School using the descriptors warranty, guaranty, and contracts. There were many recent articles and studies on reliability improvement type warranties and related issues but it was found that little information existed on warranties relating to the correction of deficient workmanship and material.

II. THE STRUCTURE, CONDUCT AND PERFORMANCE OF THE DD-963 WARRANTY GUARANTY/PROGRAM

The purpose of this chapter is to provide a brief overview of the DD-963 contract, to identify the applicable contract articles which governed the program, and to describe the manner in which the program was conducted. Article XII WARRANTY PERIOD and the standard operating procedures for implementation and execution of the warranty form the basic framework for this discussion. Analysis of the financial and maintenance data will be examined in a subsequent chapter.

A. DD-963 CONTRACT REVIEW

The DD-963 contract is the largest single shipbuilding contract ever awarded by the U.S. Navy, a total of 30 destroyers. It represents a new contracting approach wherein design, engineering, construction and fleet readiness were all provided by a single contractor under a fixed-price incentive contract. Both Litton Industries and the U.S. Navy at the time of contract award in 1970 realized it would be difficult to accurately estimate all costs that would be incurred during the eight years of ship design, engineering and production. As a result, an agreement was made on cost parameters which provided for negotiation to determine the final price for the ships midway through the contract, when more accurate estimates could be obtained. This negotiation

process went through several iterations which began in October 1973 and ended 30 July 1978. Contract modification P00064 implemented a settlement agreed on by both parties based upon an estimated total allowable cost. The Secretary of Defense determined that the agreement would facilitate national defense and could be processed under the authority of Public Law 85-804. The entire controversy surrounding the claim, court proceedings and final resolution is not considered to have had a significant effect on the execution of the Warranty/Guaranty program other than serving to indemnify the contractor from claims based on design and engineering faults as covered in Article XI of the contract. Article XI is contained in Appendix A herein; however, the effects of the article are not considered by this study. The boilerplate articles, XXII Contractor Personnel (Warranty Engineers) and XXIII Capture and Detention, are also contained in Appendix A for the convenience and reference of the reader. These articles are self explanatory in nature and do not enter into the analysis that follows. As of this writing, approximately three years after the delivery of the last ship, the DD-963 contract closeout is still being negotiated.

1. Article XII Warranty Period

The following contract article provided the majority of Warranty guidance in the DD-963 program.

ARTICLE XII. WARRANTY PERIOD

(a) The Contractor warrants that for a period of twelve (12) months of unrestricted service after delivery of each vessel constructed and delivered under this contract, each vessel shall be free from defects in material and workmanship. Upon delivery of each vessel, the Contracting Officer shall give the Contractor written notice of the proposed expiration date of this warranty. The Warranty Period shall be extended for any period in which a vessel is unavailable for unrestricted service due to defects in material or workmanship, or correction of design and engineering deficiencies under Article XI of this contract. When such defect is corrected and the vessel is again available for unrestricted service, the Contracting Officer shall give the Contractor written notice of the revised expiration date of this warranty.

(b) The Contractor may, at its own expense, maintain on board each vessel, a warranty engineer who shall be afforded every reasonable opportunity to inspect such vessel in all its parts except for such areas as may be restricted because of military security. Such warranty engineer shall have no power to direct or control the operation of said vessel or vessels. In the event a warranty engineer decides that maintenance procedures are not being accomplished or that operating procedures are not being accomplished or that operating procedures in use will in any way void any part of this warranty, he shall immediately notify the Commanding Officer of the ship, the Supervisor, the Contracting Officer, and the Project Manager, DX/DXG Project, Washington, D.C.

(c) The Contractor shall at its own expense correct any and all defects which constitute a breach or breaches of this warranty. The Government shall notify the Contractor in writing within thirty (30) days of discovery of any conditions which are deemed to be covered by this warranty. The Government shall have the option of correcting the condition aboard the vessel at its location, having the condition corrected at the nearest repair yard to the vessel's location, or, whenever the condition will not interfere with the continued operation of the vessel, having the vessel returned to the Contractor's shipyard for correction of the condition. In the event such condition requires immediate correction in order to continue the safe operation of the vessel, the Government shall notify the Contractor in writing within five (5) days after the discovery of the condition and before repair, if practicable. When due to emergency conditions or due to election by the Government corrective action is taken at a location other than the Contractor's yard, an invoice shall be furnished to the

Contractor for services rendered and shall be duly certified by the Government that:

(i) all such services were required to accomplish corrections which are deemed to be the responsibility of the Contractor under this Article;

(ii) all such services were required under emergency conditions or were required to be performed under circumstances where Contractor personnel were not reasonable available;

(iii) a copy of all data available to the Government concerning such repairs has been made available to the Contractor or will be made available upon request;

(iv) payment has been made by the Government for such services. Promptly upon receipt of any such invoice, the Contractor shall either pay the amount due, subject, however, to the "Disputes" clause of this contract or shall negotiate the amount due with the Contracting Officer.

(d) The liability of the Contractor under this warranty is limited to the correction of defects in material or workmanship in the vessels, and consequential or special damages are expressly excluded. The provisions of this Article shall not be applicable to:

(i) Government-furnished equipment, materials, and supplies, except the installation thereof;

(ii) accidents, misuse, abuse, improper operational procedures, or negligence by non-Contractor personnel;

(iii) repairs, corrections, replacements, alterations, or additions by source other than the Contractor, except under emergency conditions as herein provided.

(iv) damage caused by perils of the sea, rivers, or navigation or by exposure to unreasonable environmental conditions.

(v) replacement of DD-963 components in accordance with the Maintenance Plan;

(vi) deficiencies caused by failure of the Government to perform maintenance in accordance with the Plans of Maintenance.

(e) Failure to agree upon any determination to be made under this clause shall be a dispute concerning a question of fact within the meaning of the "Disputes" clause of this contract.

(f) The rights and remedies of the Government provided in this clause are in addition to and do not limit any rights afforded to the Government under any other clause of this contract.

(g) Prior to establishment of the combined total final price under Article XXI hereof "Incentive Price Revision (Firm Target)" and prior to establishment of the total compensation to be paid under paragraph (f) of Article IV, "Compensation Under Contracts N00024-69-c-0283 and N00024-70-C-0275", all costs incurred, or to be incurred, by the Contractor, in complying with this Article shall be considered when negotiating the combined total final price

and the total compensation under Article IV and XXI. After establishment of the combined total final price and the total compensation to be paid, Contractor compliance with this Article shall be at the Contractor's expense and at no increase in the total final price and total compensation to be paid. [Ref. 2]

2. Contract Modifications

In the course of the contract, two contract modifications affected the Warranty/Guaranty articles of the contract. Article XI was modified by P00042 on 23 July 1975. This modification imposed a $900,000.00 ceiling on the cost that the contractor could claim in providing warranty engineers and support for administration of contractor obligations under the contract provisions. Article XI was subsequently deleted in its entirety by P00064, as part of the agreement made between the Government and the contractor under the authority of Public Law 85-804 in settlement of the dispute as discussed earlier. This government concession ceded to Ingalls' contention that contractor liability for design and engineering ended upon acceptance of Ingalls' engineering plans and drawings by NAVSEA, prior to entering the production phase of the program. For the most part, these two modifications were the only ones that affected warranty coverage. Several modifications changed items from contractor provided material to government furnished which, in effect, changed contractor liability in regard to the item; however, decisions of this nature are made by the program office and the effect on the warranty coverage is considered when the decision is made.

TABLE V

USS FLETCHER - DD992

%COMP	WEEK NO	ACT. BENE	BENE LOST	NET BENE	MAR. BENE.
76.69	24	59250	18012	41238	****
77.08	25	59487	17775	41712	474
78.22	26	60435	16827	43608	1896
79.14	27	61146	16116	45030	1422
79.14	28	61146	16116	45030	0
80.06	29	61857	15405	46452	1422
80.98	30	62568	14694	47874	1422
84.05	31	64938	12324	52614	4740
84.36	32	65175	12087	53088	474
87.73	33	67782	9480	58302	5214
91.10	34	70389	6873	63516	5214
92.94	35	71811	5451	66360	2844
93.25	36	72048	5214	66834	474
94.48	37	72996	4266	68730	1896
94.79	38	73233	4029	69204	474
95.40	39	73707	3555	70152	948
96.01	40	74181	3081	71100	948
96.93	41	74892	2370	72522	1422
97.85	42	75603	1659	73944	1422
98.16	43	75840	1422	74418	474
99.69	44	77025	237	76788	2370
99.69	45	77025	237	76788	0
100	46	77262	0	77262	474
100	47	77262	0	77262	0
100	48	77262	0	77262	0
100	49	77262	0	77262	0
100	50	77262	0	77262	0
100	51	77262	0	77262	0
100	52	77262	0	77262	0

Again the authors were restricted in using average costs, but more precise data did not exist.

Tables IX, X, and XI summarize the model's output using this class average cost per 2K in the same format as Tables VI, VII, and VIII. In summary, this model appears to be relatively insensitive to changes in average cost per 2K.

TABLE VI

OPTIMUM W/G LENGTH - ACTUAL

	EFFECTIVENESS LEVEL				
	75%	80%	85%	90%	95%
USS LEFTWICH	29	30	37	38	46
USS THORN	24	29	29	29	45
USS FLETCHER	24	29	35	35	39
MEAN	25.67	29.33	33.67	34	43.33
STD. DEVIATION	2.89	0.58	4.16	4.58	3.79
COEF. OF DEV.	0.11	0.02	0.12	0.13	0.09

FIGURES IN WEEKS AFTER COMMISSIONING

•

TABLE VII

REPAIR DOLLARS REMAINING ACTUAL

	EFFECTIVENESS LEVEL				
	75%	80%	85%	90%	95%
USS LEFTWICH	32757	31683	16110	14499	4907
USS THORN	24600	9594	9594	9594	4428
USS FLETCHER	18012	15405	5451	5451	3555
MEAN	25123	18894	10385	9848	4297
STD. DEVIATION	7386	11450	5373	4529	686
COEF. OF DEV.	0.29	0.61	0.52	0.46	0.16

FIGURES IN $ OF REPAIR REMAINING

TABLE VIII

NINE MONTH W/G PERIOD(39 WEEKS)

SHIP	ACT COST	BUDGET COST	VARIANCE	ANALYSIS
USS LEFTWICH	$149286	$203000	$53714	FAVORABLE
USS THORN	92988	203000	110012	FAVORABLE
USS FLETCHER	73707	203000	129293	FAVORABLE

TABLE IX

OPTIMUM W/G LENGTH - CLASS AVE MODEL

	EFFECTIVENESS LEVEL				
	75%	80%	85%	90%	95%
USS LEFTWICH	29	30	37	38	46
USS THORN	29	29	29	29	46
USS FLETCHER	24	29	36	36	39
MEAN	27.33	29.33	34.00	34.33	43.67
STD. DEVIATION	2.89	0.58	4.36	4.73	4.04
COEF. OF DEV.	0.11	0.02	0.13	0.14	0.09

FIGURES IN WEEKS AFTER COMMISSIONING

TABLE X

REPAIR DOLLARS REMAINING CLASS AVE MODEL

	EFFECTIVENESS LEVEL				
	75%	80%	85%	90%	95%
USS LEFTWICH	40321	38999	19830	17847	5949
USS THORN	25779	25779	25779	25779	9915
USS FLETCHER	50236	42965	14542	14542	9915
MEAN	38779	35914	20050	19389	8593
STD. DEVIATION	12301	8999	5622	5775	2290
COEF. OF DEV.	0.32	0.25	0.28	0.30	0.27

FIGURES IN $ OF REPAIR REMAINING

TABLE XI

NINE MONTH W/G PERIOD (39 WEEKS) -CLASS AVE MODEL

SHIP	BUDGET COST	EST.BENE.	VARIANCE	ANALYSIS
USS LEFTWICH	$203000	$183758	$19242	UNFAVORABLE
USS THORN	203000	249858	46858	FAVORABLE
USS FLETCHER	203000	205571	2571	FAVORABLE
TOTAL	609000	639187	30187	FAVORABLE

Each ship in the class will have particular characteristics which will affect the way defective work will be discovered, and what defective work will be discovered. This in turn will affect the patterns of work discovery for that ship, and the total Warranty/Guaranty cost for that ship. These factors may be reduced in variance by uniform procedures and common, effective training on Warranty/Guaranty program management, but unique circumstances facing each ship will cause uncertainty in using average ship data as was done in this analysis. The authors recognize this problem, but feel that using average cost data in this case was still effective in highlighting possible areas of improvement in the Warranty/Guaranty program planning.

3. Non-quantifiables

In order to correctly make a decision about length of time for a Warranty/Guaranty period, considerations other than economic optimization must be analyzed. The primary non-quantifiable was driven by the ships' schedules after commissioning. Four key events seemed to drive the discovery of deficient work. These were (1) Commissioning; (2) Initial Shakedown; (3) Final Contract Trials; and (4) Post Shakedown Availability. Since the final event, Post Shakedown Availability, could not reasonably be scheduled before approximately the sixth month after commissioning (and the availability usually required approximately two to three months), Warranty/Guaranty coverage should not be less than eight months. This also allows the crew a reasonable period to operate the ship, and discover problems which might fall in the Warranty/Guaranty area.

H. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

Based on both quantifiable and unquantifiable information presented above, the following conclusions can be made:

(1) The twelve month Warranty/Guaranty program for the Spruance Class Destroyer was too lengthy.

(2) Too much money was set aside for Warranty/Guaranty items, since $42,000,000.00 was available, but only $8,119,347.00 was actually required.

2. Recommendations

Based on the model, the following recommendations are made:

(1) Nine months would be a more optimal length of time for any shipbuilding program of similar size, nature, and complexity as the Spruance Class Program. Based on the three samples, 90 percent effectiveness would have been achieved in all ships, with an average of only $9848 of repairs remaining to be handled by ship's crew. Also, the ships' initial one-year schedules would not have to be altered.

(2) The amount of money set aside for Warranty/Guaranty could be reduced to between 0.5 percent and 1.0 percent of target cost for the ships.

(a) The contract, as written, provided the following:

For 12 months at 2 percent of Target Cost =	$42000000
Actual Cost =	8119347
Excess Amount =	33880653

(b) If the Warranty/Guaranty period was reduced to nine months the following would have been provided using the same approach:

9/12 x 2% = 1.5% of Target Cost =	$31500000
Estimated Cost =	6090000
Excess Amount =	25410000

(c) If nine months at 1% Target Cost = $21000000

Estimated Cost = 6090000

Excess Amount = 14910000

(d) If nine months at 0.5% of Target Cost = $10500000

Estimated Cost = 6090000

Excess Amount = 4410000

With between four and fifteen million dollars in excess of what the model suggests is needed for the Warranty/Guaranty program, the Procurement Contracting Officer and Program Manager would have the necessary risk insurance available for the uncertainties of the shipbuilding program. Gross overestimation could be reduced.

(3) This model should serve only as an example of a lesson learned for the Spruance Class shipbuilding program. Its lessons may be applicable to length of Warranty/Guaranty periods for new shipbuilding programs, and negotiated amounts set aside for those programs. The study and judgement of Program Managers and Contracting Officers must still be the primary basis for decisions regarding new shipbuilding efforts.

IV. INTERNAL CONTROL

The purpose of this chapter is to analyze the internal control procedures utilized in the DD-963 Warranty/Guaranty program, identify any weaknesses and recommend changes that could improve future shipbuilding warranty programs.

The American Institute of Certified Public Accountants (AICPA) defines internal control as follows:

> "Internal control comprises the plan of organization and all of the coordinated methods and measures adapted within a business to safeguard its assets, check the accuracy and reliability of its accounting data, promote operational efficiency, and encourage adherence to prescribed management policies." [Ref. 4]

This definition describes systems used by management personnel in the maintenance of data base information from which they will learn and base future decisions. The system of internal control in the DD-963 Warranty/Guaranty program was established in most part by utilization of two existing Navy reporting systems. The Budget Operating Target (OPTAR) system was used to collect obligation information on material ordered and used in support of the program. The Maintenance and Material Management (3M) system was used to document and communicate discrepant work items and the number of manhours expended by Navy personnel in support of the program. The effectiveness of these systems will be reviewed in this chapter.

A. OPTAR REPORTING SYSTEM

The basic procedure used by the Navy to recoup Government funds expended in support of the Warranty/Guaranty program was discussed in Chapter II. Table XII contains the amount of money which the case study ships reported obligated via the Commanding Officers' closeout letters to the Supervisor of Shipbuilding. These figures were the amount SUPSHIP (Code 400) used as the basis for negotiation in settlement of contractor liability for Government furnished material and supplies in support of the Warranty/Guaranty program. The amount was a simple summation of the OPTAR balance in the special OPTAR account obligated by the ship until the end of the Warranty/Guaranty period. This procedure provided accurate obligation information as of the date of submission; however, due to the Navy accounting system and the basic difference between obligations and expenditures the procedure produced built-in anomalies.

An obligation is a legal reservation of funds whereas an expenditure is an actual disbursement in settlement of a government debt. Operating units order material and obligate funds to cover the estimated cost. As actual expenditures are made by paying activities in payment of the materials, the operating unit is informed by the accounting activity of the actual expenditure amount. This closes the loop and allows the operating unit to adjust its obligation amount

TABLE XII

MATERIAL EXPENDITURES

USS THORN	$7,241.15
USS LEFTWICH	$22,374.17
USS FLETCHER	$4,121.87

as necessary to bring its records into agreement with the actual amount of the expenditure.

No mechanism was employed to keep SUPSHIP (Code 400) informed of changes in OPTAR obligations. Because of the lag time in the accounting system this created the potential for significant error in the amount of money recouped from Ingalls in settlement of government furnished materials and services.

B. 3M REPORTING SYSTEM

The internal control mechanism utilized to document and communicate work items, and as a related issue manhours expended, was the 3M system as outlined in Chapter II. The authors initially intended to utilize the maintenance data base maintained by the Navy Maintenance Support Office (NMSO) as a major resource for this thesis. In theory, all 4790.2K's

written by fleet vessels are input to the data base and are available for review and study by Navy and government activities interested in studying maintenance related problems. A special report was designed by NMSO [Ref. 5]. The report was designed to sort maintenance actions by unit identification codes and the special purpose code block 46 where "WG" was to be placed on all Warranty/Guaranty 4790.2K's. The results of the effort were not satisfactory as only 2670 maintenance actions were retrieved of the 12,283 actually submitted to Ingalls warranty engineers (21.7 percent). After it was ascertained that the report was correctly prepared and no further improvement could be expected short of requesting an all inclusive report containing all maintenance actions for each unit identification code within a given timeframe, it was determined that it was simply not practical to utilize the data base as a resource. The reason for this discrepancy in reporting is addressed below.

The alternate method developed to obtain actual data was to secure contractor copies of the actual 4790.2K's submitted by three ships. Table XIII contains the number of manhours reported via the Commanding Officers' closeout letters of the case study vessels along with statistics taken from the contractor's copies of the actual 4790.2K's which were submitted. The manhour breakdown consists of the sum of the hours annotated in block 25, ship's force manhours expended, and block 27, ship's force manhours remaining, on all accepted

TABLE XIII

MANHOUR STATISTICS

	(1)	(2)	(3)	(4)	(5)	(6)
USS LEFTWICH	299	6	81	21	467	2720
USS THORN	429	31	129	31	2001	2418
USS FLETCHER	328	12	12	37	275	2959

(1) Number of 4790.2K's submitted.
(2) Number of 4790.2K's lost and unavaliable for review.
(3) Number of 4790.2K's rejected by Ingalls.
(4) Number of 4790.2K's accepted for material only.
(5) Number of manhours reported via closeout letter.
(6) Number of manhours annotated on 4790.2K's.

2K's not specifically annotated by the warranty engineer as 'material only". Table XIII also contains information on the disposition of the work items submitted.

There exists a significant spread in the figures submitted by the CO at warranty closeout and the figures tallied on the actual 2K's. After analysis this difference has been attributed to several factors:

1. Poor record keeping.
2. Work items accepted for material only, and
3. Negotiation of manhours by shipboard personnel.

1. Poor Record Keeping

There is little doubt that record keeping alone contributed to the spread in the figures in Table XII, columns

5 and 6. The fact that only 21 percent of the warranty work items could be retrieved from the NMSO data base indicates that substantial error was introduced into the system via inaccurate maintenance records keeping by shipboard personnel.

2. Materials Only Work Items

No provision was made in the contract articles for work items being accepted on a materials only basis. The case study statistics indicate 10.7 percent of all accepted work items were accepted with this caveat. This is a significant informal modification to the contract articles that was made at the shipboard level.

3. Negotiation of Manhours by Shipboard Personnel

Determination of fault for warranty items is difficult when so many variables are involved. Factors such as operator error, improper maintenance and consequential damage reach across a large "gray" area where judgement must be applied on the part of both shipboard and contractor personnel. These complexities forced both parties to seek middle ground on a number of work items. The middle ground utilized was the "material only" acceptance by Ingalls. Other impasses were solved by "horse trading" manhours for acceptance of work items that were disputable as to whether or not the contractor was at fault. These compromises were not found to be abused, but they were widely utilized to accommodate border-line work items and were clearly not provided for in the contract articles.

C. PRECOMMISSIONING CREW TRAINING

Internal control systems must be understood and utilized by managers if they are to be effective. The sophisticated crew training and phasing plan for the Spruance class destroyer program was developed and implemented to ensure that manpower assets were available and properly trained when required by the ship delivery schedule. Unfortunately, very little consideration was given in the extensive plan to providing supply and maintenance management personnel the requisite training required to understand the contract articles, their application, and the intricate process involved in the acceptance of a new construction ship for the Navy. The only formal training provided the precommissioning (PRECOM) crew was the two-hour Warranty/Guaranty lecture provided by SUPSHIP. The remainder of the learning process was to be conducted as on-the-job training. This lack of knowledge placed the PRECOM crew at a disadvantage working in a complex government and contractor management structure. The Commanding Officer was clearly charged with the responsibility of acceptance of the new construction ship. His success depended on his ability to articulate requirements via the proper channels and manage the efforts of people and organizations outside his normal chain of command. To facilitate this type of management effort a solid training program for ship's officers and chief petty officers is required.

As contained in Table XII the number of rejected work items, 222, amounted to 21 percent of the total discrepancies submitted. There were only two reasons for the rejection of these work items: either the work item involved government furnished material or it was considered to be routine maintenance and not a material failure. The repetitive submission of work items that clearly fell into these two categories indicates a low level of understanding of the Warranty/ Guaranty program by shipboard personnel. A cursory training program could have greatly improved the level of understanding of the PRECOM crew.

D. RECOMMENDATIONS

Internal control would be enhanced if the following mechanisms could be adjusted to communicate the required information to the proper manager in a timely fashion. The emphasis here is the correction of deficiencies, not the actual vehicle used. Each shipbuilding program is different in scope and the control systems will require individual structuring to meet the needs of the program.

The Supervisor of Shipbuilding should have available to him more timely information regarding the expenditure of government funds for warranty items. This could be accomplished any number of ways, such as including SUPSHIP in the reporting system or giving him the responsibility for the reimbursable fund instead of the type commander, but it is

absolutely necessary he have access to expenditure information in a timely fashion.

Provisions should be included in the contract vehicle to provide guidance regarding documentation of ship's force manhours expended and discrepancies accepted on a "material only" basis. These provisions should be written so as to grant the people on the waterfront the authority to come to terms with difficult work items and still be held accountable for their actions. By not addressing this issue, and hence allowing negotiation to occur between the ship and the Warranty Engineer without any guidance or review, no attempt to manage or maintain accountability is made.

The personnel training pipeline in the U.S. Navy for new construction ships is long and complex. That fact is recognized and no matter how much training is provided for a PRECOM crew, more could be justified. It is not the intent of this study to add to an already lengthy training pipeline; however, there was very little training provided the officers and crew on industrial management in a shipyard environment. It is essential that industrial management be understood by PRECOM personnel prior to the formation of the PRECOM crew. On-the-job training, or learning-by-mistakes is costly to the Navy as each PRECOM crew is formed of itself, and no corporate knowledge exists to guide crew members. This oversight allows the same problems to occur over and over on each ship without benefit of learning.

E. SUMMARY

The internal control system established and used in the DD-963 program using established Navy reporting routines was flexible, and encouraged adherence to management policy. However, the system did not provide the ACO with timely expenditure information nor did it provide the adequate flexibility and guidance that was required by shipboard personnel who were involved in actual negotiations regarding work item acceptance and government material and manhours expended. The system could be used as a model for future shipbuilding programs, providing the system shortcomings identified above are corrected. Caution is advised when using any control system as a model; control systems should be tailored expressly for the individual program, taking into consideration the program's own intricacies and the reporting requirements of the program managers involved.

V. CONCLUSIONS AND RECOMMENDATIONS

There are many issues confronting the Program Manager and Procurement Contracting Officer when making decisions about major shipbuilding programs. After reviewing just one, the Warranty/Guaranty decision, it appears that several lessons emerge. Conclusions are presented first, followed by recommendations.

A. CONCLUSIONS

1. The nature of modern military shipbuilding requires a mechanism for extension of contractor liability beyond the initial delivery date. Quality assurance and acceptance testing must be performed under actual conditions. Defective material and workmanship should be the responsibility of the contractor and the Government should have the right to assert claims regarding defects discovered after acceptance of the ship.

2. The DD-963 shipbuilding program represented a new contracting approach wherein design, engineering, construction and fleet readiness were all provided by a single contractor under a fixed-price incentive contract for a total of 30 modern destroyers. Lessons learned should, therefore, be applicable to shipbuilding efforts conducted under similar conditions of uncertainty and contract structure. Plans for

future shipbuilding efforts could incorporate lessons learned from this effort.

3. Even though the DD-963 shipbuilding contract was not executed totally as planned, and many problems arose during its execution which severely changed the basic contract structure, the Warranty/Guaranty effort was executed as originally conceived.

4. The management control techniques used by the ship during the Warranty/Guaranty period were the same used in normal fleet operations. The coordination between the Navy commands involved in the administration of the program was well defined and utilized the existing Navy 3M, Supply, and CASREP reporting systems to document and communicate problems that were identified. This maintained extra reporting requirements at a minimum.

5. Review of the Warranty/Guaranty effort was held on a timely basis, which allowed problems to be resolved and agreement to be gained on an incremental basis without overburdening the ship's crew.

6. The primary objectives of a Program Manager are to get a new ship delivered at or under contract cost targets, on or before required delivery date, with the minimum possible defects still in existence after acceptance by the Government. A specific Warranty/Guaranty coverage period is the best method available to achieve this, assuming no additional efficiency in inspection procedures can be achieved in the

short run, and that defective material and workmanship items will exist at time of delivery due to the complexity of the shipbuilding process.

7. The economic objective for deciding the length of time a Warranty/Guaranty program should run is to correct as much defective material and workmanship existing at the time of delivery, up to the point where the marginal benefits obtained from correction at least equal the marginal costs for the Warranty/Guaranty clause being extended an additional increment of time.

8. The twelve month Warranty/Guaranty program for the Spruance Class Destroyer shipbuilding program was too lengthy. Too much money was set aside for Warranty/Guaranty items in the initial contract, indicating an overestimation of the production uncertainties and technical problems which were actually encountered during the program.

9. No mechanism was employed in the Budget Operating Target (OPTAR) System to keep the SUPSHIP Code 400 (Administrative Contracting Officer) informed of changes in OPTAR obligations. The lag in the accounting system between obligation and actual expenditure data created the potential for significant error in the amount of money recovered in settlement of government furnished materials and services.

10. The Maintenance and Material Management (3M) System did not effectively capture data pertaining to the Warranty/Guaranty efforts of each Spruance Class ship. Only 2670

maintenance actions were retrieved from the data base at Fleet Material Support Office (FMSO) out of the actual 12,283 submitted to Ingalls warranty engineers. This was a poor 21.7 percent effectiveness.

11. Poor record keeping, work items accepted for material only, and negotiation of manhours by shipboard personnel caused a significant spread in the figures submitted by the CO at Warranty closeout from those actually recorded on discrepancy 2K's. This in turn caused a material misstatement of funds actually expended by the Navy under the Warranty/Guaranty clause, and reimbursable to the Navy by Ingalls.

12. Very little consideration was given in the extensive crew training and phasing plan for the Spruance class destroyer program for providing supply and maintenance management personnel with the requisite training required to understand the Warranty/Guaranty contract article, its implications, and the intricate process involved in accepting a new ship for the Navy.

B. RECOMMENDATIONS

1. Nine months would be a more optimal length of time for any shipbuilding program of similar size, nature, and complexity to the Spruance Class program. The ship's first year schedule could remain intact, and effectiveness in correcting deficient material and workmanship would remain at no less than 90 percent of that achieved after running the program for one year.

2. The amount of money set aside for Warranty/Guaranty items could be reduced to between 0.5 percent and 1.0 percent of target cost for shipbuilding programs of a similar complexity rather than the 2 percent thumbrule used in the Spruance class contract.

3. The Administrative Contracting Officer (in this case Supervisor of Shipbuilding) should have available to him more timely information regarding the expenditure of government funds for warranty items. This could be accomplished by including the ACO in the reporting system, or giving him the responsibility for the reimbursable fund rather than the Type Commander. In any case, the expenditure information absolutely must be made available to the ACO in a timely manner.

4. Provisions should be included in the contract to provide guidance regarding documentation of ship's force manhours expended and discrepancies accepted on a "Materials Only" basis. These provisions should give responsible agents on the waterfront the authority to resolve issues arising from difficult work item responsibilities, and still ensure accountability for their actions. Allowance of negotiations between the ship and warranty engineer without any guidance or review caused a loss of efficiency and accountability on the part of the Government for money available for recovery under the Warranty/Guaranty clause.

5. It is essential that better training on industrial management in the shipyard be afforded PRECOM crews. On-the-job training which occurred on the Warranty/Guaranty program did not provide the level of knowledge necessary to ensure efficient, effective discovery, documentation, reporting, and resolution of issues arising under the Warranty/Guaranty program.

6. These lessons learned may be applicable to shipbuilding efforts in the future. The study and judgement of Program Managers and Contracting Officers must still be the primary basis for decisions regarding these new shipbuilding projects.

APPENDIX A
WARRANTY/GUARANTY CONTRACT ARTICLES

The provisions of the DD-963 contract which provided for the Warranty program are contained in the following articles taken from the actual contract.

ARTICLE XI. PERFORMANCE, MAINTAINABILITY, AND RELIABILITY GUARANTEE

(a) The parties have agreed that when the first acceptable vessel (hereinafter referred to as the product Baseline Vessel) has been delivered to the Government (at which time Guarantee and Warranty commence) and has successfully completed its Final Contract Trials, all other vessels will be constructed in strict conformity to that Product Baseline, except for any changes therein which may be made in accordance with this contract. The contractor guarantees that, notwithstanding inspection and delivery of the vessels covered by this guarantee, it will at its own expense correct any design and engineering deficiencies in each of the vessels, provided, however, that the Plans for Maintenance are complied with, and provided further that the causes of any such deficiencies or excess maintenance are attributable to improper design or engineering and not to human error or negligence. The guarantee shall continue during the period from delivery to Final Acceptance

of the fifth vessel. As used in this Article, design and engineering deficiencies shall include deficiencies or failures in the vessel(s) which result in the failure of a system, subsystem or component to perform in accordance with the Contract Specifications.

(b) Notwithstanding inspection and Final Acceptance by the Government of each of the vessels constructed and delivered under this contract, or any provision of this contract concerning conclusiveness thereof, the Contractor guarantees that for a period of forty-eight (48) months after final acceptance of the fifth vessel, each such vessel will perform in accordance with the Contract specifications of this contract.

(c) The Contracting Officer shall give written notice to the Contractor of any breach of the guarantees in paragraphs (a) and (b) of this clause within thirty (30) days of such breach. The Government shall have the option of either correcting the condition aboard the vessel at its location, having the condition corrected at the nearest repair yard to the vessel's location, or, whenever the condition will not interfere with the continued operation of the vessel, having the vessel returned to the Contractor's shipyard for correction of the condition. In the event such condition requires immediate correction, in order to continue the safe operation of the vessel, the Government shall notify the Contractor within five (5)

days after the discovery of the condition and before repair, if practicable.

(d) Within a reasonable time after such notice, the Contracting Officer may either:

(i) by written notice require the prompt correction or replacement of any supplies or part thereof by the Contractor;

(ii) have the corrections or replacements made by a source other than the Contractor and charge the cost thereof to the Contractor. When corrective action is taken at a location other than the Contractor's yard, opportunity shall be given to a representative of the Contractor to inspect the deficiency and observe its repair, if practicable. When such corrective action is taken, due to emergency conditions or due to election by the Government at a location other than the Contractor's yard, an invoice shall be furnished to the Contractor for services rendered and shall be duly certified by the Government that:

(1) All such corrections are deemed to be the responsibility of the Contractor under this Article;

(2) All such corrections were performed under emergency conditions or under circumstances where Contractor personnel were not readily available;

(3) A copy of all data available to the Government concerning such corrections has been made available to the Contractor or will be made available upon request;

(4) Payment has been made by the Government for all such corrections.

Promptly upon receipt of any such invoice from the Contracting Officer, the Contractor shall either pay the amount due, subject, however, to the "Disputes" clause of this contract or shall negotiate the amount due with the Contracting Officer.

(e) The Contractor may, at its own expense, maintain on board each Destroyer covered by this guarantee, a guarantee engineer who shall be afforded every reasonable opportunity to inspect such vessel in all its parts except for such areas as may be restricted because of military security. Such guarantee engineer shall have no power to direct or control the operation of said vessel or vessels. In the event a guarantee engineer decides that maintenance procedures are not being accomplished or that operating procedures in use will in any way void any part of this guarantee, he shall immediately notify the Commanding Officer of the ship, the Contracting Officer, and the Project Manager, Washington, D.C. A guarantee engineer may be furnished under the provisions of this ARTICLE XI or the provisions of ARTICLE XII, but not both.

(f) The liability of the Contractor under this guarantee is limited to corrections to the vessels as herein provided, and consequential or special damages are expressly excluded. The provisions of this Article shall not be applicable to:

(i) Government-furnished equipment, materials, and supplies, except the installation thereof;

(ii) accidents, misuse, abuse, improper operational procedures, or negligence by non-Contractor personnel;

(iii) repairs, correction, replacements, alterations, or additions by a source other than the Contractor, except under emergency conditions as herein provided;

(iv) damage caused by perils of the sea, rivers, or navigation or by exposure to unreasonable environmental conditions;

(v) replacement of DD-963 components in accordance with the Maintenance Plan;

(vi) deficiencies caused by failure of the Government to perform maintenance in accordance with the Plans for Maintenance.

(g) The maximum and sole liability of the Contractor under this guarantee article and the warranty provisions (ARTICLE XII) of this contract shall be limited to $42,798,000.00 "...which amount includes, but is not limited to, the cost of providing guarantee and warranty engineers and support for administering the Contractor's obligations under ARTICLES XI, XII, and XXII of this contract, provided that no more than $900,000.00 for guarantee and warranty engineers and support shall be included in the aforesaid $42,798,000.00 (added by p00064)".

(h) The rights and remedies of the Government provided in this clause are in addition to and do not limit any rights afforded to the Government by any other clause of the contract.

ARTICLE XXII. CONTRACTOR PERSONNEL (WARRANTY ENGINEERS)

(a) The Contractor may retain representatives (hereinafter called "warranty engineers") to provide the Government with expert services in connection with "Article XI-Performance, Maintainability, and Reliability Guarantee, and Article XII, Warranty Period, hereunder.

(b) The Contractor shall be responsible for selecting personnel who are well qualified to perform the required services; to supervise techniques used in operating the ships; and to inform the parties of improvements in methods of ship operations.

(c) Contractor personnel, upon assignment, either within the continental limits of the United States or overseas, are subject to call 24 hours a day. Normally, they will perform their assigned duties on the same daily and hourly basis as the ship's company to which they are assigned. Holidays will be observed in accordance with the direction of the Commanding Officer of the vessel to which Contractor personnel are assigned.

(d) The Contractor may furnish a replacement for any Contractor personnel who may be returned to the Contractor's plant or become incapacitated, or die, or otherwise be unable to complete performance hereunder prior to the expiration of the period of performance, unless otherwise agreed upon by the parties hereto.

(e) The Contractor shall furnish all necessary equipment, salaries and wages of its personnel, all costs of subsistence and lodging, cost of passports, insurance, and and all other costs in connection with the services to be rendered except as otherwise provided in ARTICLE XXIV, hereof, entitled SERVICES FURNISHED BY THE GOVERNMENT (WARRANTY ENGINEERS).

(f) The Contractor shall furnish in writing to the Contracting Officer the name of each person assigned by the Contractor under this contract, his qualifications, his security clearance, and such other pertinent information as the Contracting Officer may request. The Contractor shall have the right to replace or transfer its personnel and to substitute other qualified personnel in lieu thereof; provided, however, that such replacements or transfers have been coordinated with the Contracting Officer. Any transfers or reassignments shall be at the Contractor's expense.

(g) The Contracting Officer may, if he finds it to be in the best interest of the Government, direct the Contractor to remove, and the Contractor shall remove, any employee from an assignment to perform services under this contract.

(h) The Contractor shall furnish to and file with the Contracting Officer copies of records of employment of such warranty engineers.

(i) Personnel employed by the Contractor hereunder and sent overseas shall be accredited to the United States Navy with a recognized status under the Hague Regulations and the Geneva Covenants, shall be given proper credentials and identification cards, shall wear a uniform when prescribed by the Theater Commander, shall be subject to appropriate recognition under the rules of war, and shall be subject to such regulations as have been or may hereafter be issued by the United States Navy governing Contractor personnel serving with the United States Navy in foreign theaters of operation.

ARTICLE XXIII. CAPTURE AND DETENTION

(a) As used in this clause:

(1) "captured person" means any employee of the Contractor-

(i) who is assigned to duty outside the United States for the performance of this contract, and

(ii) who is found to be missing from his place of employment under circumstances that make it appear probably that his absence is due to the action of the force of any power not allied with the United States in a common military effort, or who is known to have been taken prisoner, hostage or otherwise detained by the force of any such power, whether or not such person is actually engaged in his employment at the time of capture; provided that at the time the person was captured and detained that the person was either;

(A) engaged in activity directly arising out of the course of his employment under this contract, or

(B) captured in an area in which the captured person was present only because such presence was required in order to perform this contract;

(2) a "period of detention" begins with the day of capture and continues until the captured person is returned to his place of employment, or to the United States, or until his death is in fact established or legally can be presumed to have occurred by evidence satisfactory to the Contracting Officer, whichever shall occur first;

(3) "United States" comprises geographically the fifty states and District of Columbia;

(4) "War Risk Hazards Compensation Act" refers to the statute compiled in Chapter 12 of Title 42 U.S. Code (Sections 1701-1717), as amended.

(b) If pursuart to an agreement entered into prior to the capture, the Contractor is obligated to pay and shall have paid benefits to a captured person, or his dependents, on account of his detention, the Government will reimburse the Contractor for such payments up to an amount which will equal the lesser of:

(i) the total wage or salary (computed at the rate being paid at the time of capture) due from the Contractor to the captured person for the period of detention, or

(ii) that amount which would have been payable to such person if the detention had occurred under circumstances wherein the benefit provisions of the War Risk Hazards Compensation Act would have been applicable.

(c) The period of detention shall not be considered as time spent in the performance of this contract, and the Government shall not be obligated to make payment under this contract on account of such person for the period of the detention except as provided in this clause.

(d) The obligation of the Government to make payments provided for by this clause shall be applicable to the entire period of detention except that it is expressly conditioned upon and subject to the availability of funds from which payment can be made. The rights and obligations of the parties under this clause shall survive the earlier expiration, completion or termination of this contract.

(e) The Contractor shall not be reimbursed under the provisions of this clause for payments made to employees for a period of detention during which the employees were entitled to compensation for capture and detention under the War Risk Hazards Compensation Act, as amended.

ARTICLE XXIV. SERVICES FURNISHED BY THE GOVERNMENT (WARRANTY ENGINEERS)

In connection with services of warranty engineers to be rendered here-under, the Government shall furnish and supply to the Contractor the following facilities and services:

(a) Use of Government communication facilities for the exchange of messages between Contractor personnel and the Contractor, where and when available if the Contractor is unable to procure commercial communication services; but the use thereof shall be subject to the regulations of the representatives of the Government in charge thereof.

(b) Use of Government services and agencies in the transmittal of funds to Contractor personnel and as medium of commercial exchange for said personnel when adequate commercial services and facilities are not available.

(c) Contractor personnel assigned to DD-963 Class destroyers will be accorded the same privileges as commissioned officers with regard to quarters, local transportation and messing, when available. Emergency medical services may be furnished as prescribed by applicable regulations. [Ref. 2]

APPENDIX B
CHAPTER III TABLES

WORK ITEMS SUBMITTED AND TOTAL EXPENDITURES

HULL	NAME	NO. 2K's	EXPENDITURES
DD-963	SPRUANCE	431	$1,217,134.62
DD-964	PAUL F FOSTER	1083	846,250.92
DD-965	KINKAID	560	660,564.32
DD-966	HEWITT	521	547,938.67
DD-967	ELLIOT	448	406,810.58
DD-968	ARTHUR RADFORD	384	346,782.34
DD-969	PETERSON	395	219,250.48
DD-970	CARON	384	113,434.42
DD-971	DAVID RAY	581	544,747.28
DD-972	OLDENDORF	467	141,360.35
DD-973	JOHN YOUNG	499	152,209.91
DD-974	COMTE DE GRASSE	486	156,246.49
DD-975	O'BRIEN	286	395,323.76
DD-976	MERRILL	425	194,118.46
DD-977	BRISCOE	184	129,270.58

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WORK ITEMS AND EXPENDITURES (CONTINUED)

HULL	NAME	NO.2K's	EXPENDITURES
DD-978	STUMP	257	103,590.99
DD-979	CONOLLY	289	336,347.96
DD-980	MOOSBRUGGER	295	133,204.15
DD_981	JOHN HANCOCK	206	106,231.57
DD-982	NICHOLSON	238	89,342.48
DD-983	JOHN ROGERS	378	100,583.31
DD-984	LEFTWICH	299	160,489.76
DD-985	CUSHING	337	122,820.98
DD-986	HARRY W HILL	246	183,003.78
DD-987	O'BANNON	613	127,422.43
DD-988	THORN	429	105,637.27
DD-989	DEYO	241	75,366.37
DD-990	INGERSOLL	473	131,400.33
DD-991	FIFE	516	194,821.47
DD-992	FLETCHER	328	77,640.58

USS LEFTWICH DD-984 WORK ITEM ACCUMULATION BREAKDOWN

WEEK	FREQUENCY	CUM. FREQUENCY	% OF TOTAL
1	17	17	5.7
2	28	45	15.1
3	11	56	18.79
4	11	67	22.48
5	12	79	26.51
6	11	90	30.20
7	4	94	31.54
8	5	99	33.22
9	11	110	36.91
10	7	117	39.91
11	8	125	41.95
12	8	133	44.63
13	9	142	47.65
14	5	147	49.33
15	2	149	50.00
16	0	149	50.00
17	11	160	53.69
18	11	171	57.38
19	10	181	60.74
20	5	186	62.42
21	2	188	63.09
22	8	196	65.77
23	2	198	66.44
24	7	205	68.79
25	6	211	70.81
26	8	219	73.49

CONTINUED ON NEXT PAGE

USS LEFTWICH WORK ITEMS (CONTINUED)

WEEK	FREQUENCY	CUM. FREQUENCY	% OF TOTAL
27	10	229	76.85
28	5	234	78.52
29	3	237	79.53
30	2	239	80.20
31	3	242	81.21
32	3	245	82.21
33	6	251	84.53
34	5	256	85.91
35	6	262	87.92
36	5	267	89.60
37	1	268	89.93
38	3	271	90.94
39	7	278	93.29
40	1	279	93.62
41	1	280	93.96
42	0	280	93.96
43	1	281	94.30
44	0	281	94.30
45	6	287	96.31
46	2	289	96.98
47	0	289	96.98
48	0	289	96.98
49	4	293	98.32
50	1	294	98.66
51	2	296	99.33
52	2	298	100.00

USS THORN DD-984 WORK ITEM ACCUMULATION BREAKDOWN

WEEK	FREQUENCY	CUM. FREQUENCY	% OF TOTAL
1	42	42	10.40
2	44	86	21.29
3	13	99	24.50
4	8	107	26.49
5	8	115	28.47
6	5	120	29.70
7	7	127	31.44
8	2	129	31.93
9	12	141	34.90
10	2	143	35.40
11	5	148	36.63
12	5	153	37.87
13	4	157	38.86
14	17	174	43.07
15	26	200	49.50
16	11	211	52.23
17	13	224	55.45
18	18	242	59.90
19	21	263	65.10
20	17	280	69.31
21	8	288	71.29
22	2	290	71.78
23	7	297	73.51
24	7	304	75.25
25	9	313	77.48
26	18	331	81.93

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USS THORN WORK ITEMS (CONTINUED)

WEEK	FREQUENCY	CUM. FREQUENCY	% OF TOTAL
27	13	344	85.15
28	18	362	89.60
29	3	365	90.35
30	4	369	91.54
31	2	371	91.83
32	2	373	92.33
33	1	374	92.57
34	0	374	92.57
35	2	376	93.07
36	0	376	93.07
37	1	377	93.32
38	0	377	93.32
39	1	378	93.56
40	1	379	93.81
41	0	379	93.81
42	0	379	93.81
43	1	380	94.06
44	2	382	94.55
45	4	386	95.54
46	3	389	96.29
47	5	394	97.52
48	10	404	100.00
49	0	404	100.00
50	0	404	100.00
51	0	404	100.00
52	0	404	100.00

USS FLETCHER DD-992 WORK ITEM ACCUMULATION BREAKDOWN

WEEK	FREQUENCY	CUM. FREQUENCY	% OF TOTAL
1	38	38	11.66
2	56	94	28.83
3	22	116	35.58
4	31	147	45.09
5	7	154	47.24
6	5	159	48.77
7	5	164	50.31
8	4	168	51.53
9	6	174	53.74
10	13	187	57.36
11	17	204	62.58
12	1	205	62.88
13	0	205	62.88
14	9	214	65.64
15	3	217	66.56
16	1	218	66.87
17	1	219	67.18
18	3	222	68.10
19	1	223	68.40
20	4	227	69.63
21	4	231	70.86
22	3	234	71.80
23	5	239	73.31
24	11	250	76.69
25	1	251	77.00
26	4	255	78.22

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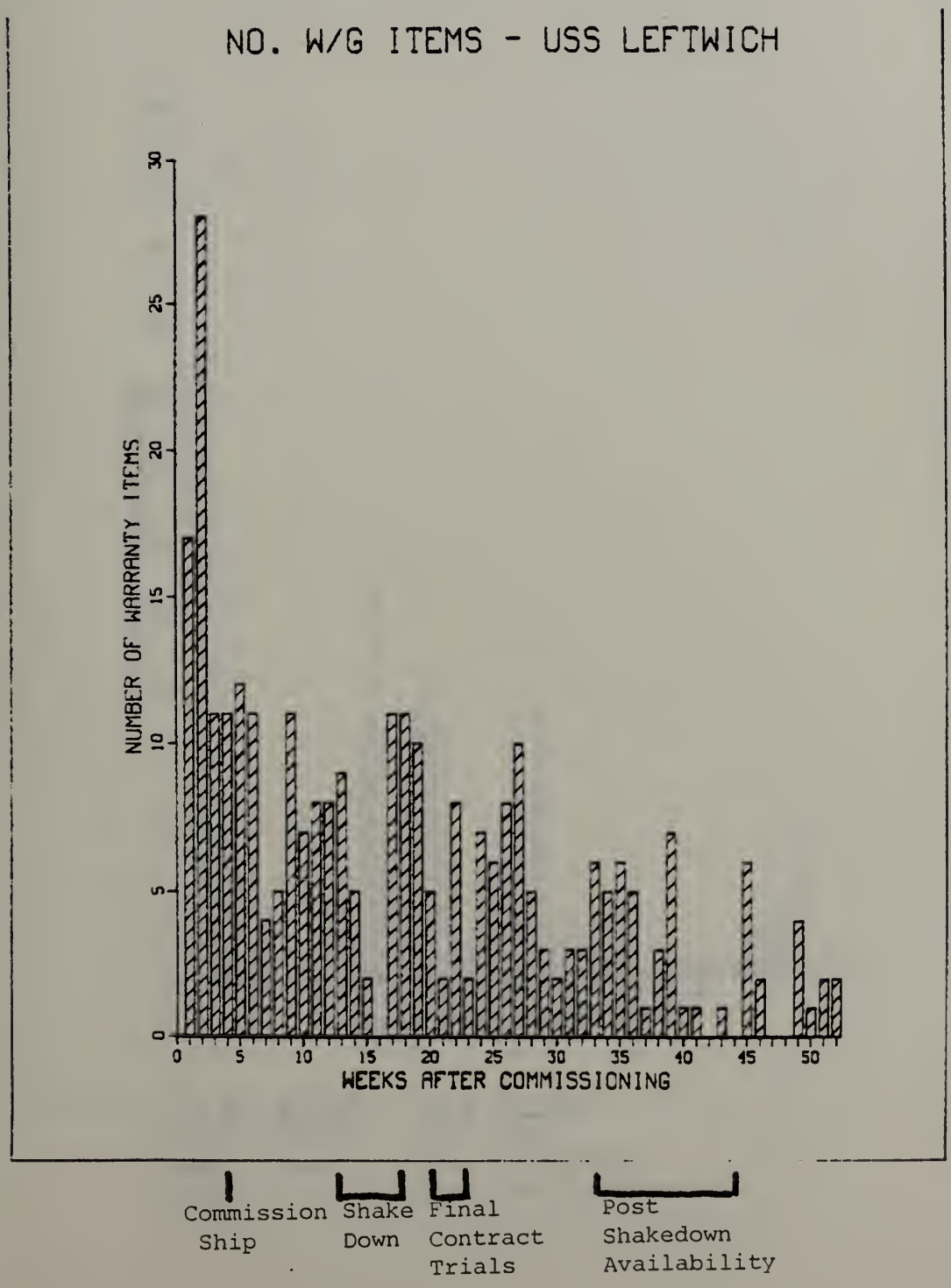
USS FLETCHER WORK ITEMS (CONTINUED)

WEEK	FREQUENCY	CUM. FREQUENCY	% OF TOTAL
27	3	258	79.14
28	0	258	79.14
29	3	261	80.06
30	3	264	80.98
31	10	274	84.05
32	1	275	84.36
33	11	286	87.73
34	11	297	91.10
35	6	303	92.94
36	1	304	93.25
37	4	308	94.48
38	1	309	94.79
39	2	311	95.40
40	2	313	96.01
41	3	316	96.93
42	3	319	97.85
43	1	320	98.16
44	5	325	99.69
45	0	325	99.69
46	1	326	100.00
47	0	326	100.00
48	0	326	100.00
49	0	326	100.00
50	0	326	100.00
51	0	326	100.00
52	0	326	100.00

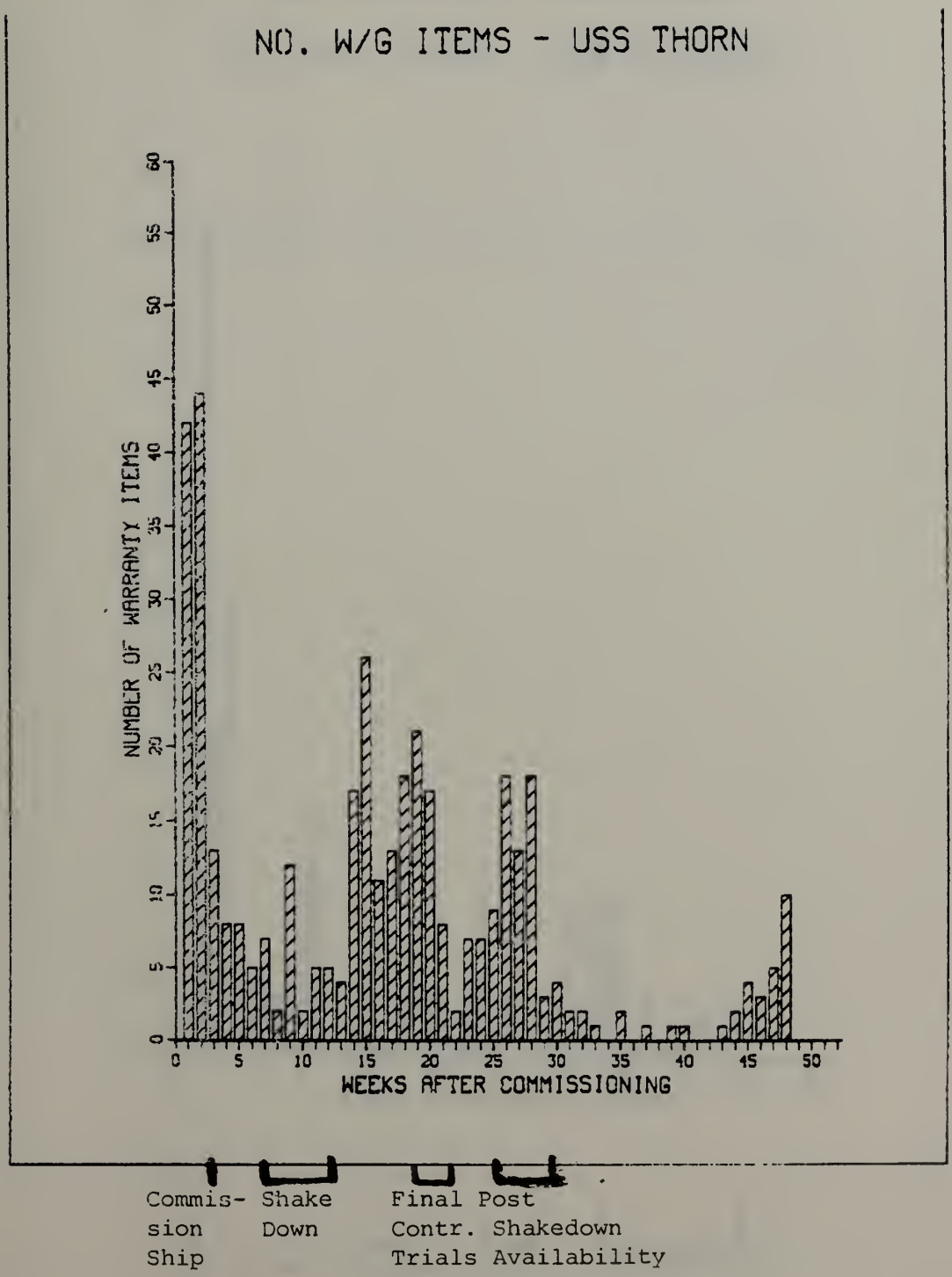
APPENDIX C

NO. W/G ITEMS - USS LEFTWICH



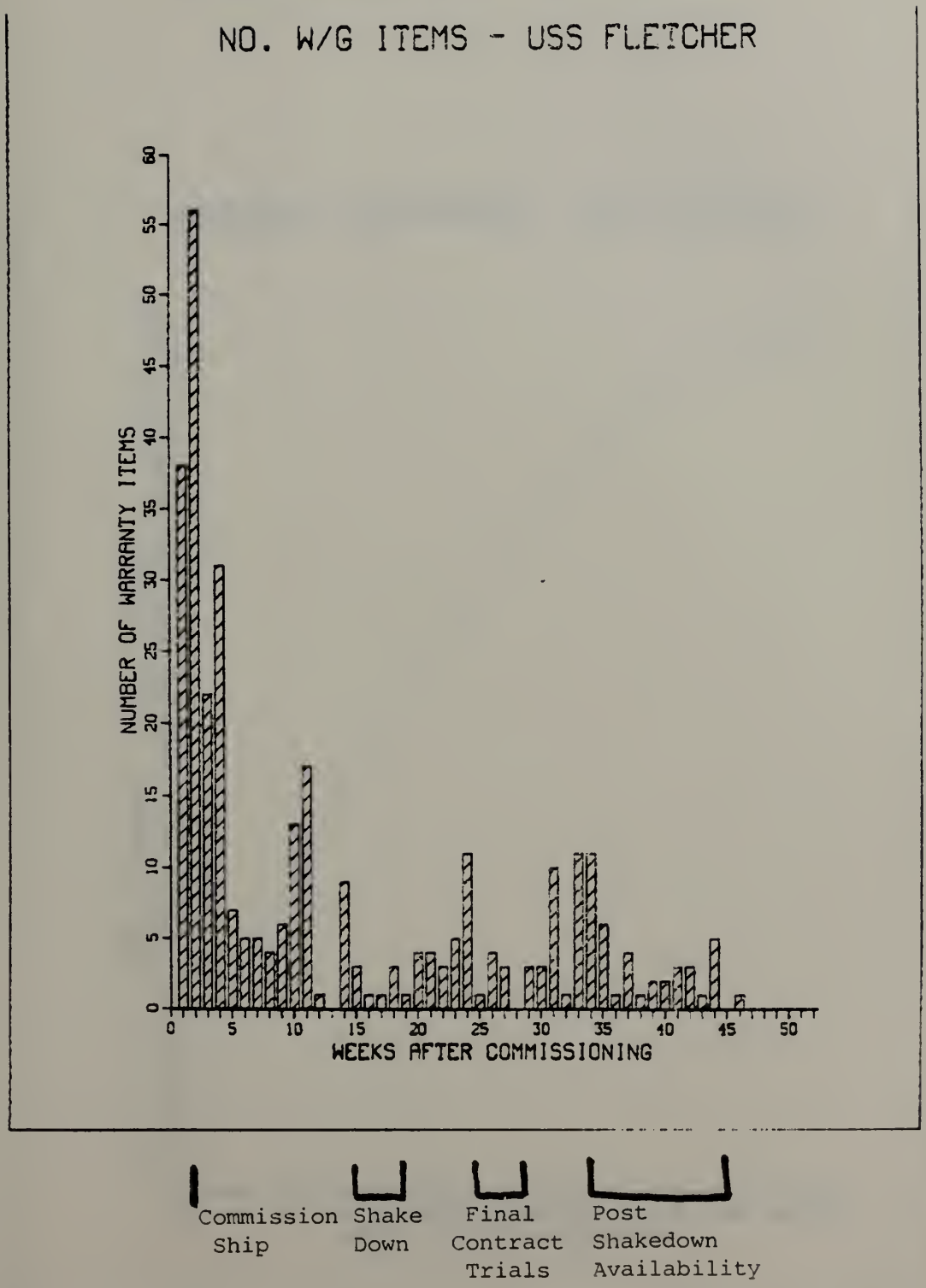
APPENDIX D

NO. W/G ITEMS - USS THORN



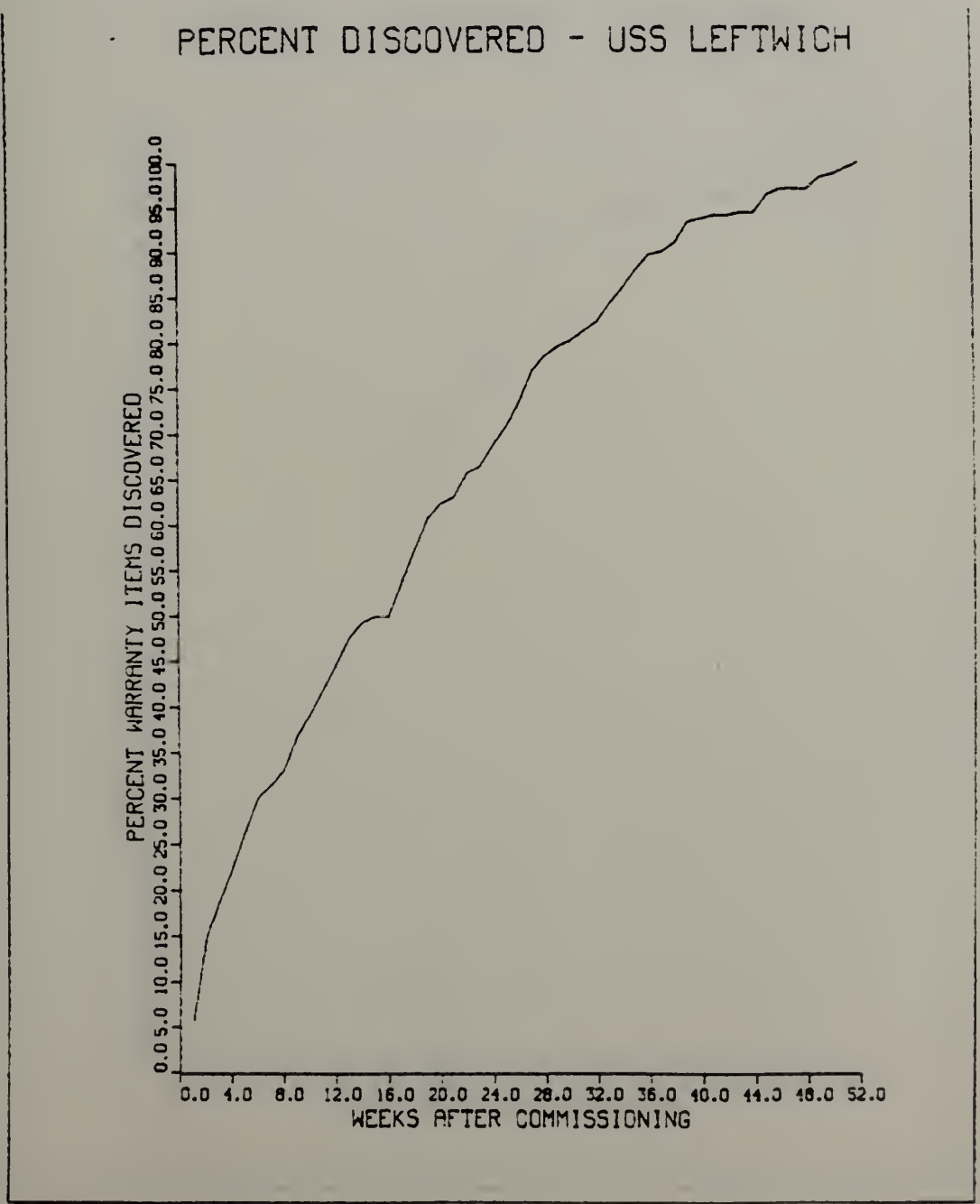
APPENDIX E

NO. W/G ITEMS - USS FLETCHER



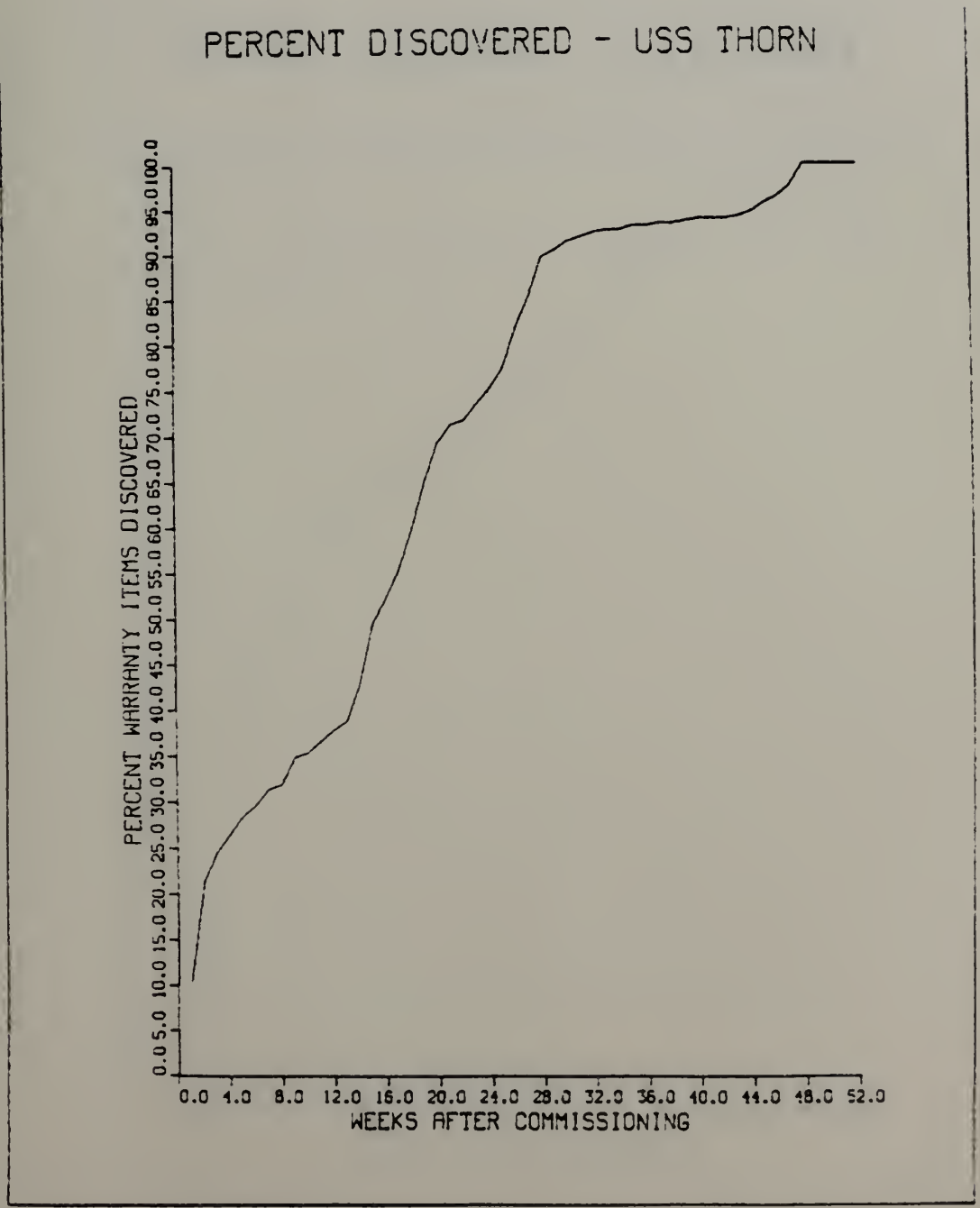
APPENDIX F

PERCENT DISCOVERED - USS LEFTWICH



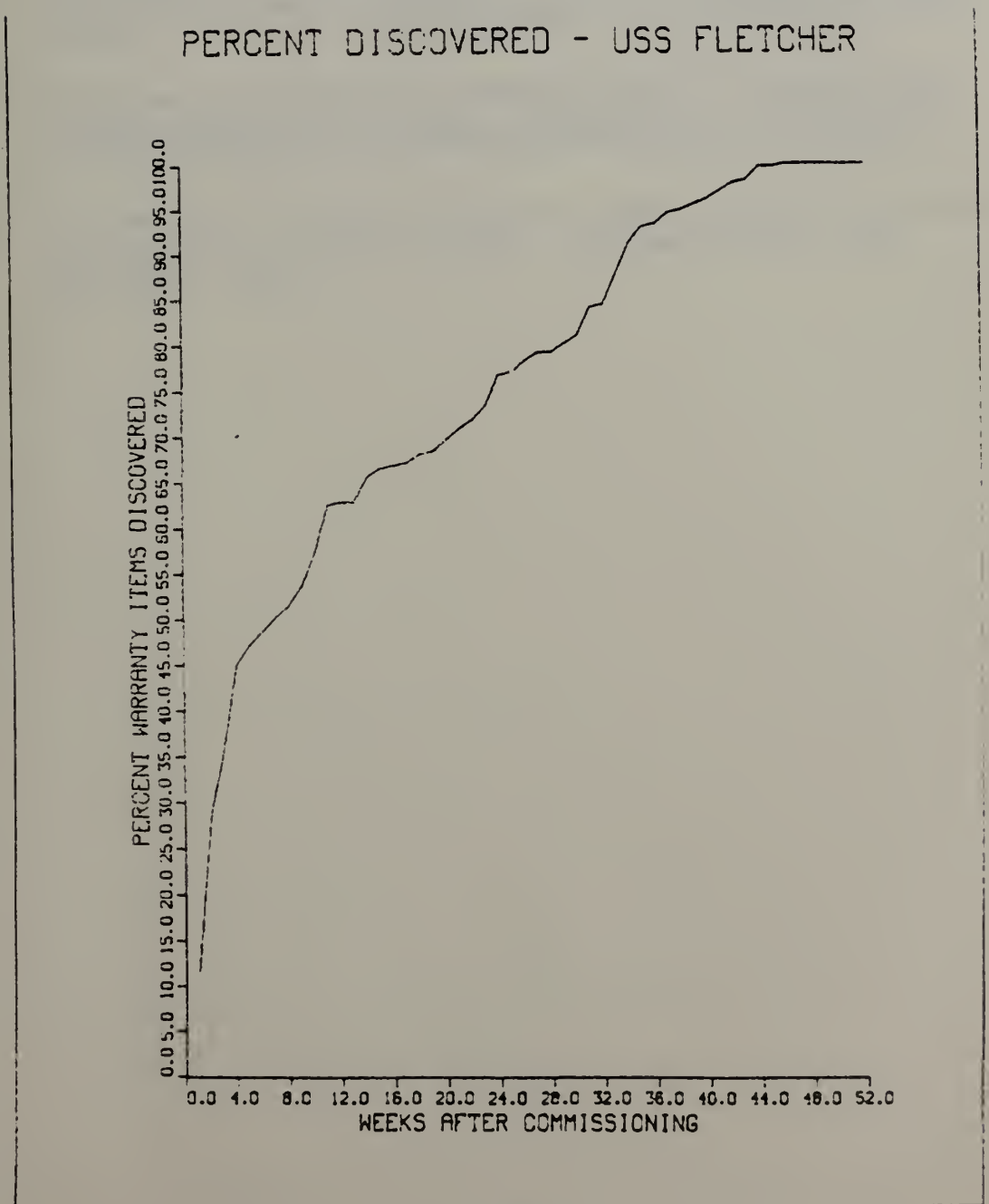
APPENDIX G

PERCENT DISCOVERED - USS THORN



APPENDIX H

PERCENT DISCOVERED - USS FLETCHER



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